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A Review of Isolation Gowns in Healthcare: Fabric and Gown Properties

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Abstract

The threat of emerging infectious diseases including Ebola hemorrhagic fever, pandemic influenza, avian influenza, Hepatitis B, Hepatitis C, and SARS has highlighted the need for effective personal protective equipment (PPE) to protect healthcare workers (HCWs), patients, and visitors. PPE is a critical component in the hierarchy of controls used to protect HCWs from infectious hazards. HCW PPE may include gowns, respirators, face masks, gloves, eye protection, face shields, and head and shoe coverings. Important research has been conducted in certain areas, such as respirators and protective masks, but studies in other areas, particularly gowns, are scarce.

Gowns are identified as the second-most-used piece of PPE, following gloves, in the healthcare setting. According to the Centers for Disease Control and Prevention's Guideline for Isolation Precautions, isolation gowns should be worn to protect HCWs' arms and exposed body areas during procedures and patient-care activities when anticipating contact with clothing, blood, bodily fluids, secretions and excretions. Isolation gowns currently available on the marketplace offer varying resistance to blood and other bodily fluids depending on the type of the material, its impermeability, and wear and tear. While some studies show no benefit of the routine use of isolation gowns, others demonstrate that its use is associated with a reduced infection rate. This paper reviews isolation gowns in healthcare settings, including the fabrics used, gown design and interfaces, as well as critical parameters that affect microorganism and liquid transmission through fabrics.

Keywords

isolation gown; blood borne pathogen; liquid transmission; protective clothing; healthcare

INTRODUCTION

In the United States, more than 18 million people work in the healthcare field. There is an increasing concern among healthcare workers (HCWs) over exposure to microorganisms that are commonly carried through blood, body fluids, and other potentially infectious

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materials (OPIM) such as, Ebola hemorrhagic fever, Hepatitis B (HBV), Hepatitis C (HCV), and Human Immunodeficiency Virus (HIV). All four previously-mentioned pathogens can be acquired via contact of contaminated body fluids with non-intact skin or mucous membranes. Isolation techniques have conventionally been used to minimize the spread of infections by controlling or eliminating infectious agents and reservoirs, interrupting the transmission cycle, and protecting susceptible patients [1]. U.S. hospitals established conventional isolation procedures at the turn of the last century, after the adoption of isolation precautions advocated by Grancher in a children's hospital in Paris [2]. It is well-documented that HCWs are at risk to acquire infections during patient-care activities [3–7]. Because of these risks, the Occupational Safety and Health Administration (OSHA) mandated the use of universal precautions during treatment of all patients in 1991 to minimize HCWs' risks of acquiring blood borne pathogens [8]. This rule requires that HCWs wear personal protective equipment (PPE) and employers to provide HCWs with appropriate PPE, such as gowns, laboratory coats, eye protection, masks, face shields, and gloves. PPE is a critical component of isolation precautions and used widely in healthcare facilities as part of the strategy to minimize passage of microbes to patients and exposure of HCWs and visitors to infectious agents, especially blood borne pathogens. The rule mandates that blood or OPIM must not reach the employee's work clothes or street clothes, undergarments, skin, eyes, mouth, or other mucous membranes. According to the rule, the required PPE type depends on the condition, type, duration, and the amount of exposure.

The Centers for Disease Control and Prevention (CDC) has categorized three primary routes of contact between people in healthcare settings and microorganisms: (i) contact (direct and indirect), (ii) respiratory droplets, and (iii) airborne droplet nuclei [9]. Contact transmission is generally considered the most common and direct contact occurs when microorganisms are transferred directly from one person to another. Airborne transmission occurs by dissemination of either airborne droplet nuclei or small particles in the respirable size range containing infectious agents [9]. Droplet transmission refers to respiratory droplets which are generated through coughing, sneezing or talking. By using appropriate protective clothing, it is possible to create a barrier to eliminate or reduce contact and droplet exposure, and therefore prevent the transfer of microorganisms between patients and HCWs. While effective PPE could provide protection from these exposures, all isolation gowns available on the market may not provide adequate protection to the wearers [1]. In addition, the isolation gowns used in the U.S. are not designed to prevent the airborne transmission; however, due to their structural properties, some reduction may occur to a variable degree. This paper highlights important issues regarding isolation gowns, including, fabric and design properties of gowns and critical parameters that impact bacterial and liquid transmission through fabrics.

OCCUPATIONAL EXPOSURE IN THE HEALTHCARE INDUSTRY

HIV, HCV, and HBV are found in high concentrations in some bodily fluids. In blood, the concentration of HIV can be as great as 10^3 particles/ml, that of HBV can be as great as 10^8 particles/ml, and that of HCV can be as great as 10^6 particles/ml [10]. Occupationally acquired HIV, HCV and HBV infections, among others, have resulted in several HCWs deaths [11]. Hence there is great need for adequate protection against contamination [1]. In

addition to the Blood borne Pathogens Rule published by OSHA, organizations such as the CDC have promulgated guidelines for HCW protection, recommending vaccination, early patient screening, isolation precautions, and the use of PPE. According to the Bureau of Labor Statistics data, the U.S. labor force is composed of approximately 130 million persons, 7.6 million of whom are HCWs with potential patient contact [12]. Approximately half of these are registered or licensed practical nurses. An additional 4 million staff work in healthcare-support occupations and may have patient contact. Sepkowitz et al [11] estimates that 17–57 HCWs per million employed die annually from occupational infections and injuries and 9–42 HCWs per million die annually from occupational infections only. According to the data which represents the average annual occupational deaths during 3-year period, 2000–2002, the number of HCW deaths is the third highest after construction worker and truck driver occupational deaths in the U.S. When the death rates per million workers are compared, HCW death rates becomes the 8th highest number in 12 occupations listed [11]. HCWs working in areas such as emergency rooms, clinical laboratories, operating rooms, etc. and Emergency Medical Services (EMS) workers are at greatest risk since they are directly exposed to blood [13].

SURVIVAL OF MICROORGANISMS ON PPE AND ROLE OF TEXTILES

Transmission of infectious agents in healthcare settings requires three elements: a source of infectious agents, a susceptible host with a portal of entry receptive to the agent, and a mode of transmission for the agent. Sources of infectious agents in the hospital include patients (bodily fluids, secretions, and excretions), HCWs, visitors, textiles (e.g., drapes, clothing, sheets, towels, and blankets), medical equipment, and other surfaces. Some organisms can survive several months on virtually any surface with patient or HCW contact, hence proper use of PPE is crucial in preventing the contact transfer of infections to patients, visitors, and other HCWs [14–19].

In addition, PPE may be contaminated during patient care activities by microorganisms spread by contact, droplets or aerosols from patients' body fluids. A variety of barriers are used alone or in combination to protect mucous membranes, skin, and sometimes clothing (scrubs, etc.) from contact with infectious agents in the environment. However they may have the potential to transmit microorganisms from one place to another [17–18]. Rates of detection of Methicillin-Resistant *Staphylococcus aureus* (MRSA) or Vancomycin-Resistant *Enterococci* (VRE) on the gowns and/or gloves of HCWs involved in either standardized or routine clinical care have been reported as low as 4% and as high as 67% [20]. A number of studies found frequent contamination of nurses' uniforms and transmission of bacteria through uniforms. Babb et al [21] reported that *S. aureus* was found on cotton coats (12.6%), plastic aprons (9.2%) and HCW's uniforms (15%) in an isolation ward. Wiener-Well [22] found that HCWs' coats and uniforms were frequently contaminated with potentially pathogenic bacteria; 85 of 135 uniforms (63%) and 50% of all samples (238) were positive for pathogenic organisms. Pilonetto et al [23] analyzed the microbiota from the uniforms of 31 professionals from an intensive care unit and found a significant increase in the total viable counts of microorganisms at the end of the period compared with those obtained at the beginning.

Bacteria and viruses can survive for extended periods on materials that comprise PPE [19]. The persistence of pathogens on textiles depends greatly on the type of microorganism. While some bacteria die within a few minutes during drying procedures, others can survive for several months [24–25]. Depending on the material and the relative humidity of the air, the persistence of viruses can range from a few weeks to several months [26]. Neeley and Maley [27] determined the survival of 22 gram-positive bacteria (vancomycin-sensitive and -resistant *enterococci* and methicillin-sensitive and -resistant *staphylococci*) on five common hospital materials: clothing, towels, scrub suits and lab coats, privacy drapes, and splash aprons by inoculating the swatches with a microorganism. They found that all isolates survived for at least one day, and some survived for more than 90 days on the various materials.

A number of studies show textiles play a critical role in the chain of infection caused by microorganisms such as bacteria and viruses [24, 26–31]. Also, several others reported the dissemination of the microorganisms through textiles or PPE [21, 26, 29, 32–34]. Hence healthcare institutions pay particular attention to textiles and their correct cleaning and maintenance as part of infection control strategies. In 2006, Nicas and Sun developed a mathematical model to describe the risk of infection for HCWs from textile-based pathogens [35].

DEFINITION, PURPOSE AND HISTORY OF ISOLATION GOWNS

Gowns are identified as the second-most-used piece of PPE, following gloves, in the healthcare setting [36–37]. Isolation gowns are defined by Association for the Advancement of Medical Instrumentation (AAMI) as the protective apparel used to protect HCWs and patients from the transfer of microorganisms and body fluids in patient isolation situations [38]. The Food and Drug Administration (FDA) also defines isolation gowns similarly: “a gown intended to protect healthcare patients and personnel from the transfer of microorganisms, body fluids, and particulate material”. It is also specified that the isolation gown covers the torso and clothing, and poses a physical barrier to the transfer of microorganisms and other materials [39].

Currently, there is confusion in the marketplace over the terminology of gowns – isolation gowns, cover gowns, precaution gowns, and protective gowns. The term “cover gown” is used to define “isolation gown” or sometimes a gown with no barrier claim. In fact, a "cover gown" is an article of clothing (not a medical device) worn over an operating room (OR) scrub suit/dress when OR personnel leave the OR suit (e.g., to go to lunch) to prevent soiling of the OR scrubs outside of the OR. OR scrub suits/dresses are required to be clean and to not bring extraneous dirt or microbes into the OR suit. If a cover gown is not worn when someone wearing scrubs leaves the OR, policies require that the exposed scrubs be removed and replaced by a new scrub suit/dress when the HCW returns to the OR suite. The terms “protective gown” and “precaution gown” are also used to define isolation gowns in the marketplace. Sometimes, protective gowns are used to refer to impervious gowns with a high level of protection. However, these terminologies are not used in the FDA classification of medical devices/regulatory guidance or CDC guidelines. Additionally, “non-surgical isolation gown” is also a term used for referring to isolation gowns, despite the fact that no

isolation gowns are used during surgeries and there are no such “surgical isolation gowns”. The problem in the definition of isolation gowns results in confusion to the end users during selection and use, and brings the risk of being unprotected or not sufficiently protected from infectious diseases. Infectious blood that leaks through gowns is a potential source of disease transmission when skin integrity is compromised, whether from preexistent lacerations, dermatitis, or other conditions.

Historically, isolation gowns are used as a cover in isolation cases to protect the HCWs from the transfer of microorganisms and were made of 100% cotton or 50/50 cotton/polyester. Old style isolation gowns offered minimal protection because of absorption of liquids and extensive washing of the products leading to fabric deterioration. Isolation gowns were considered relatively inexpensive to purchase [40]. According to the CDC’s Guideline for Isolation Precautions: Preventing Transmission of Infectious Agents in Healthcare Setting 2007 [9], isolation gowns should be worn to protect HCWs’ arms and exposed body areas during procedures and patient-care activities when anticipating contact with clothing, blood, bodily fluids, secretions and excretions. Many different types of isolation gowns are currently available to HCWs with varying protection levels. The need for, and type of isolation gown selected, is based on the nature of the patient interaction, including the anticipated degree of contact with infectious material and potential for blood and body fluid penetration of the barrier. When applying Standard Precautions (minimum infection prevention practices that apply to all patient care, regardless of suspected or confirmed infection status of the patient), isolation gowns (and gloves) are worn only if contact with blood or body fluid is anticipated. However, when Contact Precautions are used for patients infected or colonized with pathogens known to be transmitted by direct contact, donning of both gown and gloves upon room entry is required to address contact with patient and unintentional contact with contaminated environmental surfaces [9].

FABRICS USED IN ISOLATION GOWNS

Isolation gowns found in the marketplace today are produced from a variety of fabrics and a wide range of fibers. Isolation gowns are generally classified as “disposable/single-use” or “reusable/multi-use”. In the U.S., disposable isolation gowns are used more commonly, while in Europe the share of reusables is larger. Approximately 80% of hospitals in the U.S. use single-use gowns and drapes [41].

Disposable (single-use) isolation gowns are designed to be discarded after a single use and are typically constructed of nonwoven materials alone or in combination with materials that offer increased protection from liquid penetration, such as plastic films. They can be produced using a variety of nonwoven fiber-bonding technologies (thermal, chemical, or mechanical) to provide integrity and strength rather than the interlocking geometries associated with woven and knitted materials. The basic raw materials typically used for disposable isolation gowns are various forms of synthetic fibers (e.g. polypropylene, polyester, polyethylene). Fabrics can be engineered to achieve desired properties by using particular fiber types, bonding processes, and fabric finishes (chemical or physical treatments). Reusable (multi-use) gowns are laundered after each use. Reusable isolation gowns are typically made of 100% cotton, 100% polyester, or polyester/cotton blends. These

fabrics are tightly woven plain weave fabrics that are chemically finished and may be pressed through rollers to enhance the liquid barrier properties. Reusable garments generally can be used for 50 or more washing and drying cycles. The number of laundering/drying cycles is suggested by the manufacturer. According to AAMI-TIR11:2005 guidance document [38], a verifiable tracking system, such as a manual check off, bar code, or radio frequency chip, a verifiable tracking system, must be in place.

BACTERIAL AND LIQUID TRANSMISSION THROUGH FABRICS

Microorganism movement through fabrics depends on several factors, including: (i) the shape and surface characteristics of the microbe, (ii) the characteristics of carriers, (iii) the physical and chemical characteristics of the fabric.

The shape of microorganisms varies and this will impact their ability to move through a fabric structure. Microorganism characteristics including, cell size and morphology, motility, and adaptation to environmental extremes are specific to the type of microbe. Several different microorganisms have been found in healthcare settings including bacteria, viruses and some fungi. In general, fungi are larger than bacteria (1–5 /μm long), and bacteria are larger than viruses (e.g., the size of the HIV virus is ~ 13 nanometers) [42].

Microorganisms are transported by carriers such as, body fluids, shedding skin cells, lint, dust, and respiratory droplets. It has been found that most surgical site infections (SSIs) are caused by germs originating from either the staff or the patient [43–44]. It has been also reported that the presence of liquids facilitates microbial transfer and therefore increases the probability of an infection [42]; however the transmission can occur with or without liquids.

CRITICAL GOWN PROPERTIES AFFECTING BARRIER PERFORMANCE

Fabrics and Fabric Components

Since fibers are the smallest unit of gown fabrics and gown properties depend on chemical and physical properties of fibers. Physically, the length and the surface of the fiber are critical for the barrier properties of the fabric. Fibers with irregular surfaces/ cross-sections and shorter in length are more effective in preventing the transmission of particles. Fabrics made from very thin and fine fibers, such as microfibers, are generally preferred to be used for manufacturing barrier materials with higher protection. Chemically, the absorbency of the fiber is critical for liquid transmission properties of the gowns. When highly absorbent fibers are present, the fabric absorbs the liquid and as a result, bacteria can be trapped within the fiber structure. If low absorbent or hygroscopic fibers are used for the gown construction, the liquid will wick along the fiber surface, enhancing capillary movement of liquid which contains microorganisms. Natural fibers (e.g., cotton, wool, silk, etc.) have higher absorbency capabilities compared to synthetic fibers, including polypropylene and polyester, which are commonly used for the construction of isolation gowns.

The amount of twist used for the yarns also affects the fabric barrier properties. Important fabric characteristics that impact barrier properties include pore and surface characteristics. Pore size, geometry, and distribution characteristics change with the fabric construction types (knit, woven, nonwoven). Woven and nonwoven are the two most commonly used

fabric construction techniques for isolation gowns. Knitting technology is used generally for most of the reusable gown cuffs. The random orientation of the fibers in the nonwoven fabrics successfully reduces liquid transmission by (i) providing filtering media (ii) reducing the capillary formation [45]. The most commonly used nonwoven fabrics for isolation gowns are spunbond and spunbond/meltblown/spunbond technologies.

For some medical procedures, the barrier properties of one ply material may not be adequate for the particular application; in these cases, additional materials are often added in the form of additional layers of material, coating, reinforcements, or laminates in order to obtain composite materials. In addition, product attributes can be enhanced to impart absorbency, slip resistance, additional strength or other desirable characteristics [38].

Gupta [46] identified four factors that affect capillary absorption as: (i) characteristics of the fluid (surface tension, viscosity and density), (ii) the nature of the surface (surface energy and surface morphology), (iii) interaction of the fluid with the surface (interfacial tension and contact angle), and (iv) pore characteristics (size, volume, geometry and orientation).

Several studies have identified that the fabric properties, such as repellency, pore size, fabric thickness, and wicking have an impact on the barrier effectiveness [42, 47]. Leonas and Jinkins showed that fabrics with smaller pore sizes have improved barrier effectiveness to bacterial transmission [42, 47]. Sometimes, liquid carriers which help move the particle also may act as a lubricant and/or energy provider. Hence, the particle may be transferred through the fabric even if the pore size of the fabric is smaller than the bacterial particle size.

Penetration and permeation are two of the terms often used interchangeably to describe the transfer of air, liquids, and microorganisms from one side of a textile material to the other side. However, there is a fundamental difference between them. Penetration is usually defined as the bulk flow of gases, vapors, or liquids through porous materials and is driven by a pressure gradient across the barrier. Whereas, permeation is the diffusion of gases or vapors through porous materials and dissolved gases, vapors, or liquids through nonporous materials on a molecular level. In addition, permeation is driven by a concentration gradient across the barrier. If penetration can occur through the pores and imperfections in the clothing material, then permeation can also occur. Currently, microorganisms are thought to penetrate and not permeate through materials, mainly due to their larger size in comparison to gas and vapor molecules [60].

The repellency of a fabric surface is increased by reducing the surface energy. Surfaces generally become smoother and shed liquids more readily than rough surfaces when the repellent finishes are applied. Among a number of chemical classes of repellent finishes, fluorocarbon-based finishes are most commonly used in hospital gowns which repel both water and oil-based liquids. Flourocarbon-based finishes provide a fabric that is water resistant, but can be susceptible to penetration due to pressure increase or penetration by liquids of low surface tension, such as isopropyl alcohol [48–49]. It has been reported that although a fabric is effectively treated to improve repellency, once wet, regardless of the wetting solution, it is no longer an effective barrier in the prevention of bacterial transmission [42]. It has been shown that when repellent finishes are applied to fabric that

have previously not prevented bacterial transmission, the barrier properties are improved [45, 50]. However, some microorganisms may penetrate the fabric even when no liquid penetration is visible. In addition to repellent finishes, more recently antibacterial finishes, which can kill or inhibit the growth of microorganisms, have been used more widely, especially for the reusable gowns [47, 51]. Gowns treated with antimicrobial finishes may effectively reduce the cross-transmission of bacteria.

Gown Design and Interfaces

The design of the gown and interfaces can also contribute to the barrier performance in addition to the fabric properties.

The characteristics of an ideal gown have been well defined in the literature and summarized by Rutala and Weber [52]. Some of the characteristics of an ideal gown listed are: barrier effectiveness, functionality or mobility, comfort, cost, strength, fit, time to don and doff, biocompatibility, flammability, odor, and quality maintenance.

The interfaces are as critical for the protection of HCWs as the fabrics used for the gowns. The construction of a garment, particularly in critical locations such as the glove-gown interface, can render it ineffective. The area most vulnerable to strike-through (the extent of liquid penetration through the fabric) were found to be the cuff, forearm, thigh, chest, and abdomen [53]. A study examining those areas found that 70% to 80% of the gowns reported leakages [54]. Leakage often occurred in the gown/glove interface [50, 54–55].

In general, gowns sold on the marketplace currently have three different types of cuffs: elastic around the wrist (disposable) or cotton or cotton/polyester blend knit cuffs (disposable and reusables), and thumb loops (disposable and reusables) (*see* Figure 1). According to ANSI/AAMI PB70 classification [56], cuffs are not considered as a critical zone, so the material used on the cuff does not necessarily have barrier protection. In order to eliminate the strike-through through the cuffs, gloving over the cuff is strictly recommended. However this may not provide adequate protection depending on the task performed and amount of blood involved. One of the latest solutions to keep the gown wrist in place is thumb loops. Meyer and Beck [54] proposed a gown redesign that creates a dart at the terminal forearm, sealed by a liquid-proof method and then similarly sealing the proximal end of the glove to the sleeve.

There are generally three types of neck closure used on the market for isolation gowns: Tie, tape tab, and hook and loop neck closures (*see* Figure 2). Some gowns featuring hook and loop neck closures are manufactured for easy adjustability, and tape tab neck closures are for ease and reduce the time for donning and doffing. Gowns featuring a hook and loop style neck closure allow the neckline to easily adjust to variety of sizes. Neck closures and donning difficulty are identified as some of the most common issues with isolation gowns according to a survey conducted among HCWs recently [59]. An isolation gown should be designed in such a way that it fits the HCW and offers ease of donning and doffing, as the time needed for putting on and removing can be especially critical for emergency room personnel or EMS workers.

Sizing/fit is also one of the characteristics that is critical for the protection and comfort of HCWs who wear isolation gowns. In the marketplace, different size options (small, medium, etc.) are offered in addition to universal sizing (one size fits most). It has been determined that the universal size sometimes does not adequately fit the workers. The gowns must allow adequate freedom for HCWs to move, designed to fit a diversity of body shapes and sizes, and are easy to put on and remove without contaminating the worker or the workplace [57]. Poorly fitted garments may cause blood or OPIM to easily reach the skin or other clothing. CDC recommends that several gown sizes should be available in a healthcare facility to ensure appropriate coverage for staff members [9].

FACTORS THAT IMPACT THE DESIGN AND DEVELOPMENT OF ISOLATION GOWNS

The design and development of gowns or any other PPE are influenced by four factors: regulation, degree of protection, comfort, and cost.

PPE devices, including isolation gowns, that are intended for use in preventing disease in healthcare are considered as medical devices, and are subject to regulation in the U.S. The FDA is the principal agency in the U.S. for approving PPE for use by HCWs. Isolation gowns used in healthcare are regulated as Class I (general controls) devices by FDA. Class I devices including isolation gowns are considered as low risk to the wearers and normally exempt from the premarket notification requirements. The basic requirement for isolation gowns is that the manufacturer meets general standards for good manufacturing processes. Requirements regarding the use of PPE in the healthcare are overseen by the OSHA along with state and local agencies and employers. There are no mandatory standards that drive device selection and use, and certification is not mandatory either.

Many organizations have published guidelines for the use of PPE, including isolation gowns, in the U.S. healthcare settings. These organizations include CDC, Association of periOperative Registered Nurses (AORN), OSHA, and AAMI.

For isolation gowns, there is no standard that specifies the performance and design criteria. The only standard available currently for isolation gowns is ANSI/AAMI: PB70 [56], and it establishes a system of classification based on liquid barrier protection. A new Task Group (American Society for Testing and Materials (ASTM) International WK33313 - New specification for non-sterile isolation gowns intended for use in health care facilities) was formed in ASTM's F23 Committee on Protective Clothing and Equipment, with FDA and CDC's participation, to develop a specification standard for non-sterile isolation gowns recently. Development of a standard is intended to improve users' understanding of levels of protection to be provided.

Manufacturers generally make compromises during the design and development of products while trying to achieve the maximum degree of protection with the highest level of comfort and at the lowest possible cost. Because comfort has been described as one of the most critical characteristics for PPE compliance in healthcare, it is essential to design gowns that are protective and at the same time comfortable (thermally and physically) [58].

According to a recent survey [59] conducted by Association for Professionals in Infection Control and Epidemiology (APIC) and ASTM among 1498 infection control professionals; gown features could have moderate to very high impact on HCWs compliance (48%). The features believed most likely to discourage compliance were: restricts movement, time to use/remove, ease of donning/doffing, thermal comfort and gown fit. Content analysis of open ended questions of this survey revealed issues related to large sized clients, neck designs, tie closures and breathability (thermal comfort).

Several design issues exist with the current isolation gowns. According to ANSI/AAMI PB70 [56], the entire isolation gown, including the seams, but excluding the cuffs, hems and bindings, has to achieve a barrier performance of at least Level 1 which is the lowest barrier performance defined by ANSI/AAMI PB70. However some isolation gowns available on the market are made using an open-back design due to comfort concerns, but these gowns cannot be ANSI/AAMI PB70 rated. Also, the back of some gowns are not designed in such a way that there is an overlap of the fabrics in the back of the body, as in the case with surgical gowns. Due to this design, if the garment does not fit the HCW properly, this may cause an opening at the back of the garment which can be critical for blood/OPIM transfer. Ties on the abdomen or torso (Figure 3) are a common feature used for isolation gowns; however, it has been determined that they are not tied properly or sometimes not tied at all, which may cause other hazards. The isolation gown ideally should not restrict the movement of the body and should be breathable and comfortable to wear for long periods.

CONCLUSION

PPE is a critical component of the hierarchy of controls used to protect people in the hospital environments. Gowns are critical elements of the PPE since they are the second-most-used piece of PPE, following gloves.

Several reasons have been identified by HCWs regarding why they choose not to wear PPE. These reasons include time to don the equipment especially in emergency response situations, availability of equipment and/or training, comfort or difficulty in use, the equipment interference with HCW interaction with the patient, effect on dexterity or medical procedure performance ability, and HCW's wrong judgment of the situational risk [58]. Half of these barriers could be achieved by appropriate PPE development and the other half through education and other methods, such as providing the resources of adequate staffing, supplies, and other critical support measures, development of PPE standards to help purchasing units for more appropriate PPE selection. In terms of PPE development, a number of fabric characteristics (pore size and distribution, tear, seam, and puncture resistance, etc.) impact the performance of isolation gowns. The design of the gown, size, fit and interfaces can also contribute to the effectiveness and compliance, in addition to the fabric properties. Design and performance characteristics vary as a result of trade-offs in cost, comfort and the amount of barrier protection provided. The need for and type of isolation gown selected should be based on the nature of the patient interaction, including the anticipated degree of contact with infectious material and potential for blood and body fluid penetration of the barrier, anticipated volume of blood, body fluids, OPIM or other liquids, and duration of procedure or activity being performed. End users are recognized as

the best judges of the barrier level required, based on experience and the potential of known exposure risks. However, since end-users have limited information on the performance of the existing isolation gowns in the marketplace, guidance documents or standards that specify the minimum performance and design requirements for isolation gowns can help them and infection prevention and control departments/infection preventionists in healthcare settings greatly in the selection of the most appropriate gown for use.

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FIGURE 1.
Different wrist designs for isolation gowns (elastic cuff, knit cuff, and thumb loops from left to the right) (courtesy of Medline Industries, Inc.)

FIGURE 2.
Different neck closures for isolation gowns (hook and loop and tape tab neck closures from left to the right) (courtesy of Medline Industries, Inc.)

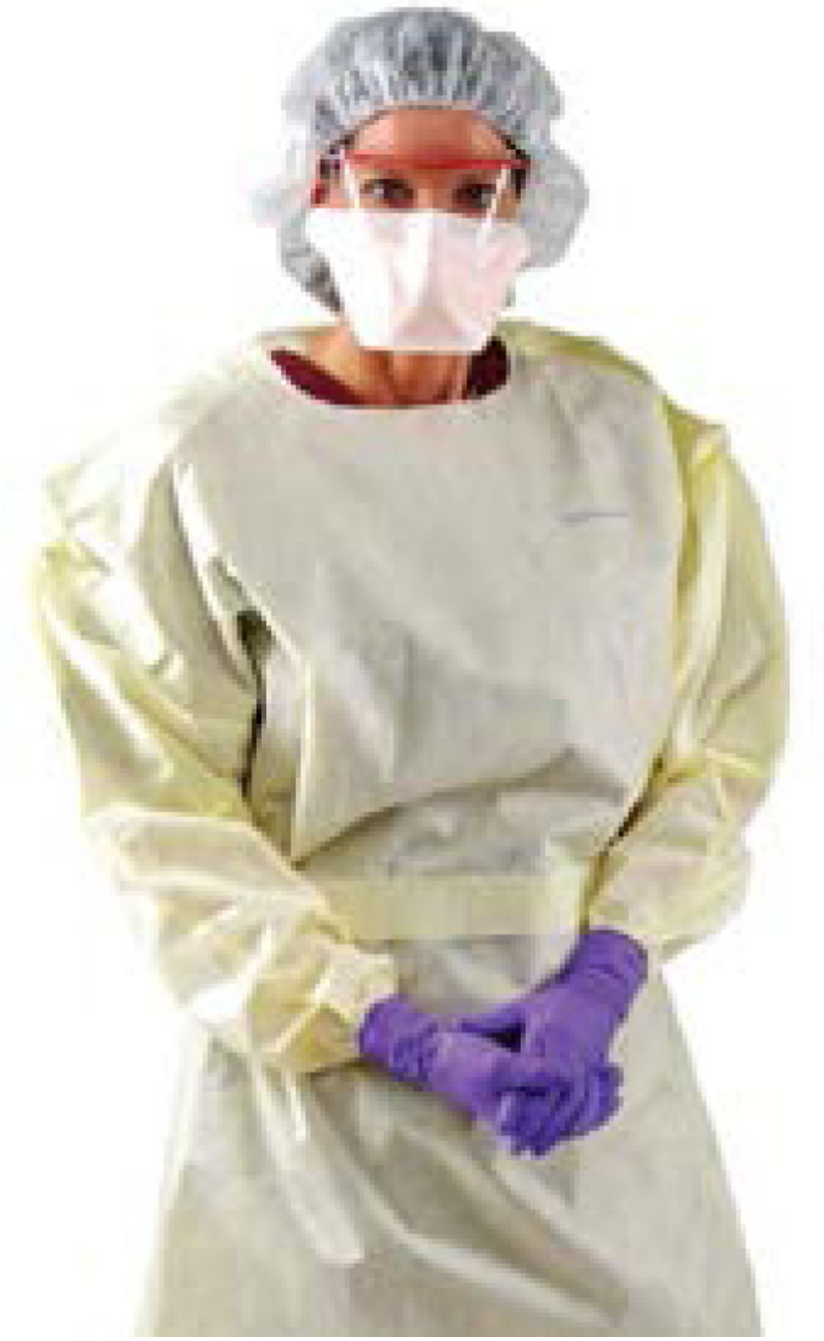

FIGURE 3.
Isolation gown with an abdominal tie (courtesy of ©Kimberly-Clark Worldwide, Inc.)